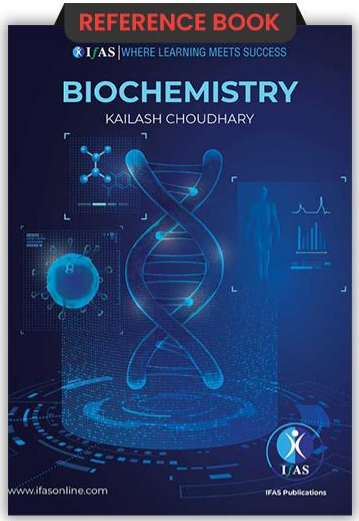
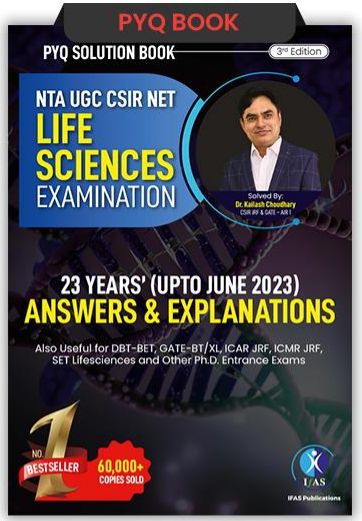
**Just one small positive thought in the morning can change your whole day…**

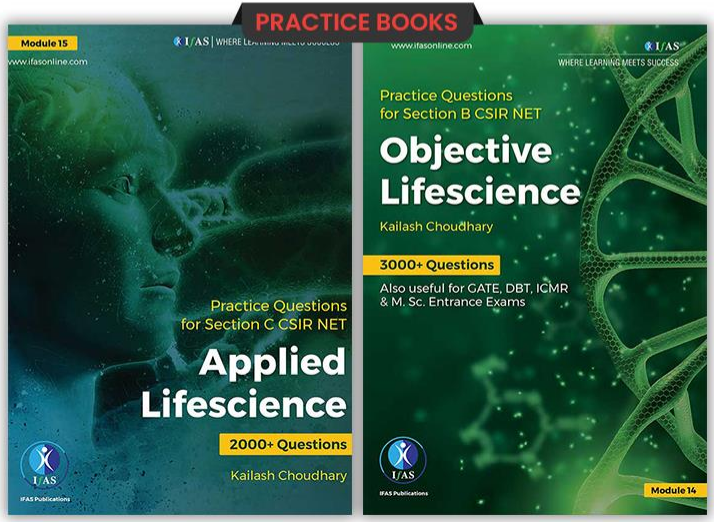
# CSIR NET – Life Science

## Unit 1: Biochemistry

**01** **Atom and Molecules**

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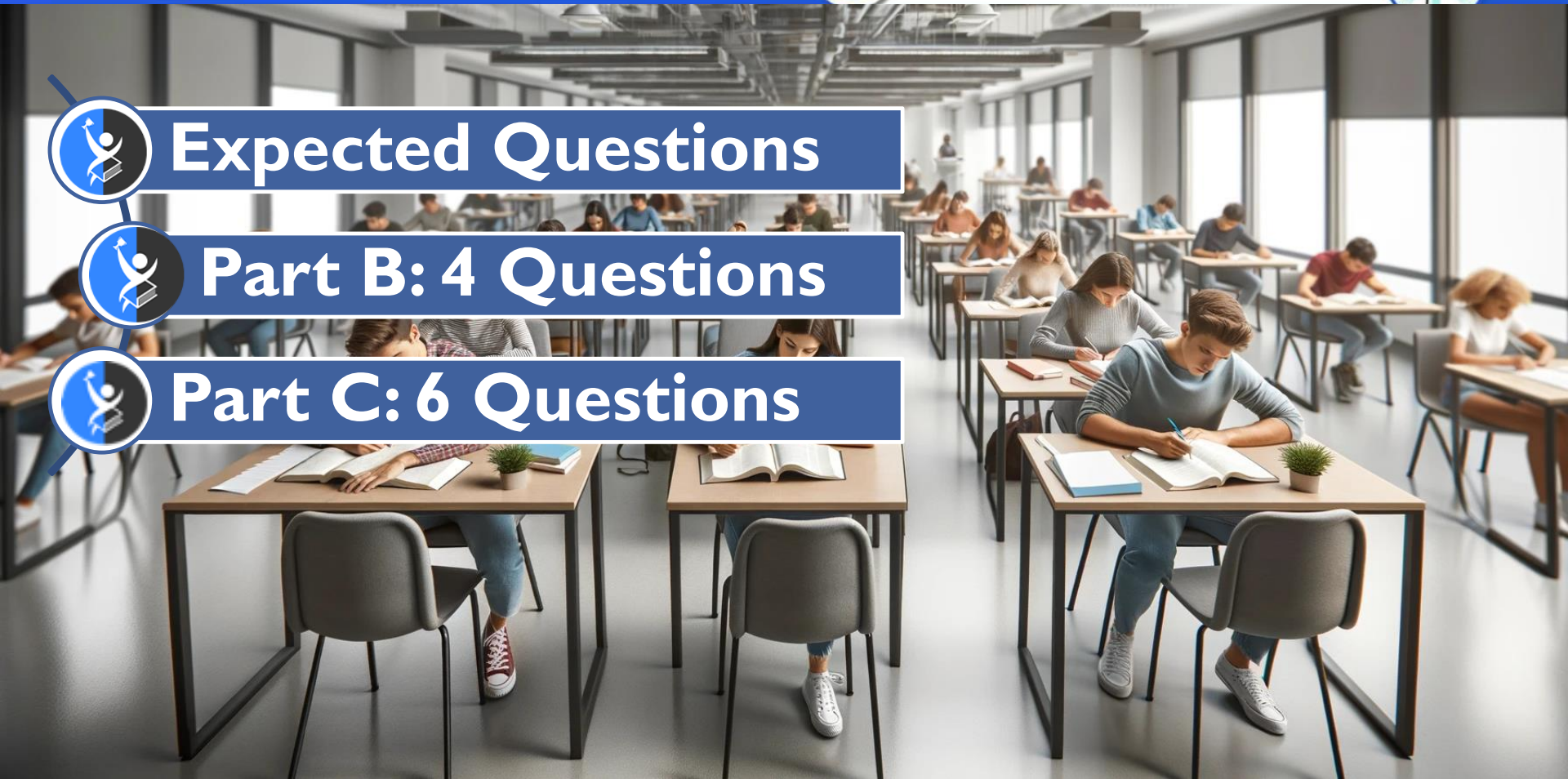


## Expected Questions

## Part B: 4 Questions

## Part C: 6 Questions

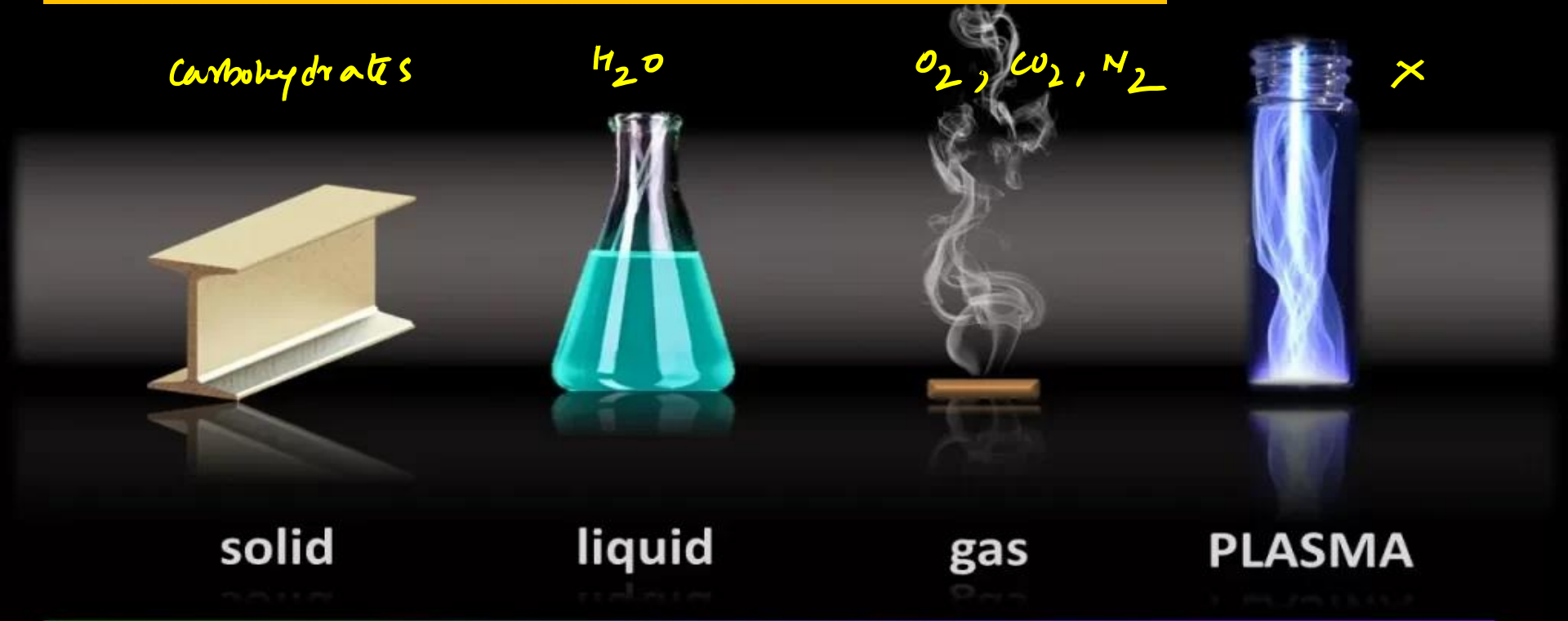
# Biochemistry

| | J13 | D13 | J14 | D14 | J 15 | D15 | J16 | D16 | J 17 | D17 | J18 | D18 | J19 | D19 | N20 I | N20 II | F22 I | F22 II | S22 I | S22 II | J23 I | J23 II | D23 I | D23 II |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Molecules & Bonds | 1- | - | - | - | - | - | 1 | - | - | - | - | - | 1 | - | - | - | - | 1 | - | - | 1 | - | - | 1 |
| Biomolecules | 2 | 1 | 3 | - | 2 | 2 | 1 | 2 | 2 | 2 | - | 1 | 2 | 2 | - | 1 | 3 | 2 | 1 | - | 2 | 2 | 1 | 1 |
| Stabilizing Interactions | - | - | 1 | - | - | 2 | 1 | - | - | - | 1 | - | 1 | - | - | - | - | - | - | 1 | - | 1 | - | - |
| Biophysical Chemistry | 1 | 1 | - | - | 2 | - | - | - | - | 1 | - | 1 | 1 | - | - | - | - | - | - | - | 1 | 1 | 1 | - |
| Bioenergetics | - | 3 | 1 | - | - | 1 | 1 | 1 | - | - | 1 | - | 1 | - | 1 | - | - | - | 1 | 1 | 1 | - | - | |
| Principles of Catalysis | 2 | 1 | 3 | 2 | - | 2 | 1 | 1 | 3 | 1 | 1 | 3 | 1 | 3 | 3 | 4 | 1 | 2 | 2 | 2 | 1 | 2 | - | 1 |
| Proteins | - | 4 | 1 | 2 | 2 | 1 | 2 | 1 | 2 | 1 | 2 | 2 | 1 | - | 4 | 2 | 1 | 2 | 2 | - | - | - | 1 | 1 |
| Nucleic Acids | - | - | - | 1 | - | - | 1 | 1 | 2 | 3 | 1 | 1 | 2 | 1 | - | - | 1 | 2 | 1 | - | 1 | 1 | 1 | 1 |
| Stability of Proteins and Nucleic acids | 1 | - | - | 1 | - | 1 | 1 | 2 | - | - | - | - | - | - | - | - | 2 | 1 | - | - | - | 1 | 1 | 1 |
| Metabolism | 1 | - | - | 3 | 1 | 3 | 2 | 2 | 1 | 1 | 2 | 2 | - | 2 | 1 | - | 3 | 2 | 2 | 2 | 4 | 2 | 4 | - |
| Oxidative Phosphorylation | - | - | 1 | - | 3 | - | - | 2 | 1 | 1 | - | - | - | - | 1 | 1 | 1 | 1 | 1 | - | - | - | - | 1 |

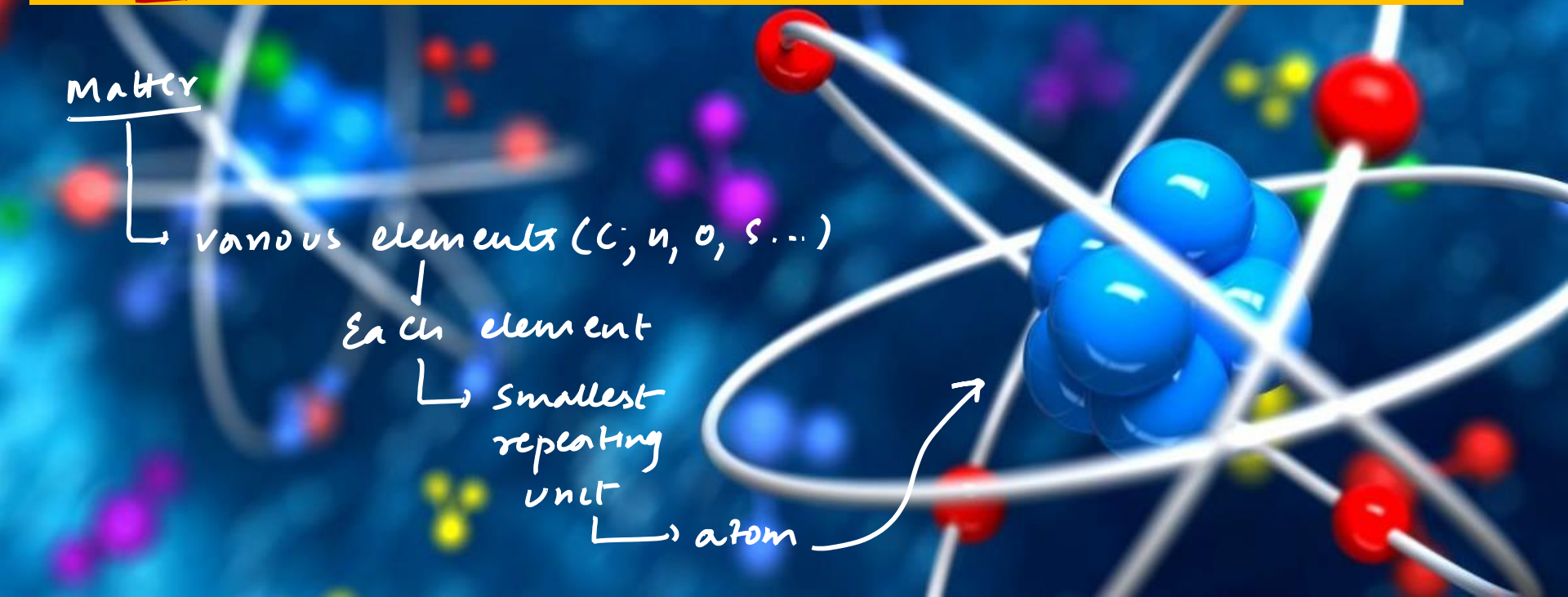
## Points to be covered in this Lecture

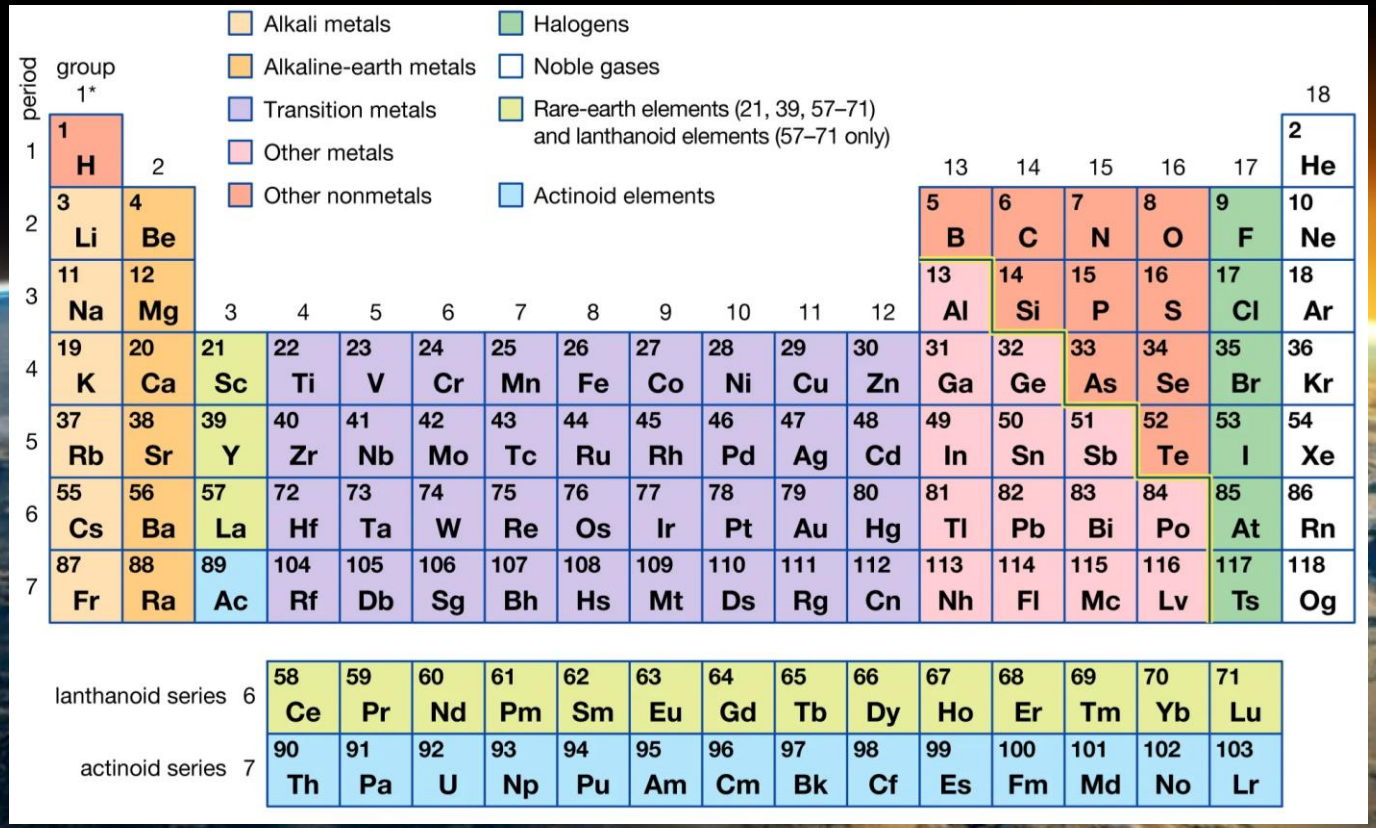
- What is Matter and its forms?
- Structure of Atom
- Atomic Number and Mass Number
- Isotopes and Radio-isotopes
- Arrangement of electrons
- What is molecule?

Matter *is anything that has mass and volume (takes up space).*



An **atom** is the smallest particle of an element that retains its chemical properties.






**Total 118 Elements are Known**

**94 are natural**

# ELEMENTS OF LIFE

25-27 elements

6 major elements

| 1A | | | | | | | | | | | 3A | 4A | 5A | 6A | 7A | 8A |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| H | 2A | | | | | | | | | | | | | | | He |
| Li | Be | | | | | | | | | | B | C | N | O | F | Ne |
| Na | Mg | 3B | 4B | 5B | 6B | 7B | 8B 8 | 8B 9 | 8B 10 | 1B | 2B | Al | Si | P | S | Cl | Ar |
| K | Ca | Sc | Ti | V | Cr | Mn | Fe | Co | Ni | Cu | Zn | Ga | Ge | As | Se | Br | Kr |
| Rb | Sr | Y | Zr | Nb | Mo | Tc | Ru | Rh | Pd | Ag | Cd | In | Sn | Sb | Te | I | Xe |
| Cs | Ba | La | Hf | Ta | W | Re | Os | Ir | Pt | Au | Hg | Tl | Pb | Bi | Po | At | Rn |

- Red, most abundant
- blue, next most abundant
- Green, trace amounts.

## Six Elements **CHNOPS elements are common**

**Table 2:** The Structural elements of protoplasm. The common elements in cell have been highlighted.

| Period | Group | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | I | II | III | IV | V | VI | VII | VIII |
| 1 | **H** | | | | | | | He |
| 2 | Li | Be | B | **C** | **N** | **O** | F | Ne |
| 3 | Na | Mg | Al | Si | **P** | **S** | Cl | Ar |

Carbohydrate : C, H, O
Lipids : C, H, O
Protein : C, H, O, N, S
DNA / RNA : C, H, O, N, P

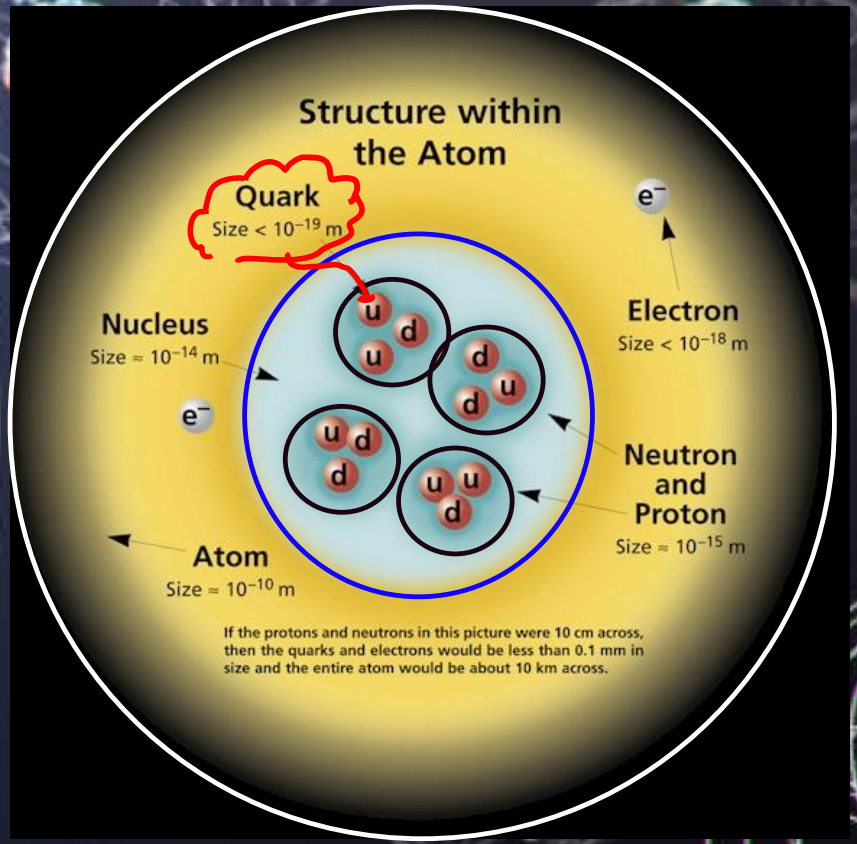
Small size

Small Size:

- High Surface area to volume ratio
- Strong bonding

Nucleus
Protons, Neutrons
Quarks, leptons

## Structure of atom



## Mass and Charge of Proton, neutron and electron

Neutral Atom
Proton = electron
Net charge = 0

| Particle | Charge | Mass (amu) |
|---|---|---|
| Proton | Positive (1+) | 1.0073 |
| Neutron | None (neutral) | 1.0087 |
| Electron | Negative (1−) | $5.486 \times 10^{-4}$ |

← nucleus
⊕ charge

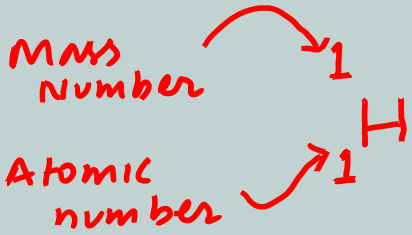
- Protons and electrons are the only particles that have a charge.
- Protons and neutrons have essentially the same mass.
- The mass of an electron is so small we ignore it.

mass of 1 proton = $1.67 \times 10^{-24}$ g

1 electron = $\frac{1 \text{ proton}}{1840}$

## What is atomic number?

- It represents number of protons ✓
- Chemical Properties of atom ✓
- Position in Periodic table ✓




| Element | Atomic Number |
|---|---|
| Hydrogen | 1 |
| Carbon | 6 |
| Nitrogen | 7 |
| Oxygen | 8 |
| Phosphorus | 15 |
| Sulphur | 16 |

## What is Mass number?

- It represents number of protons + number of neutrons
- May be variable for same element

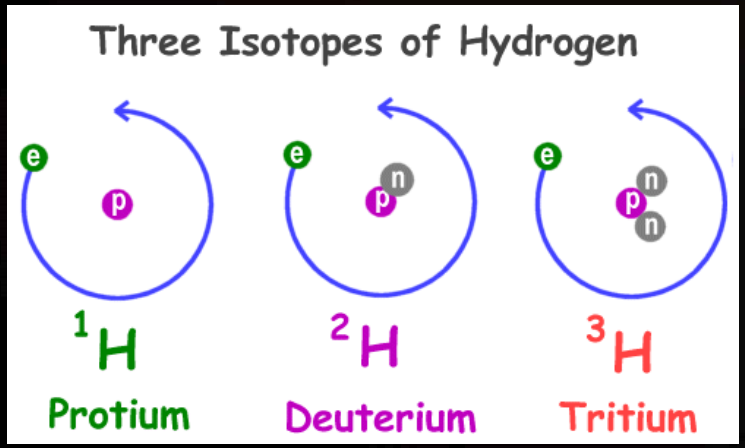
| Element | Mass Number |
|---|---|
| Hydrogen | 1 |
| Carbon | 12 |
| Nitrogen | 14 |
| Oxygen | 16 |
| Phosphorus | 31 |
| Sulphur | 32 |

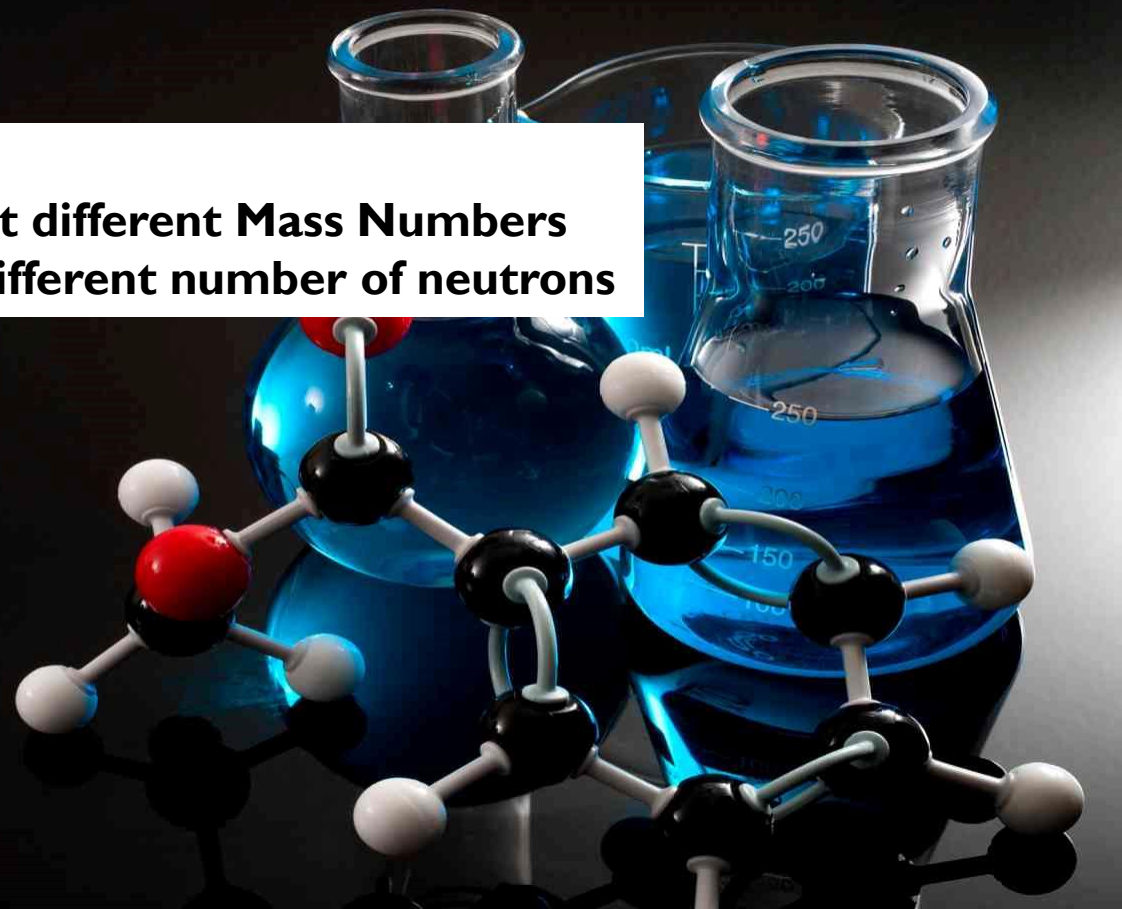
Hydrogen Atom

| | | | |
|---|---|---|---|
| | P = 1 | P = 1 | P = 1 |
| | N = 0 | N = 1 | N = 2 |
| Mass | 1 | 2 | 3 |
| | $_{1}^{1}H$ | $_{1}^{2}H$ | $_{1}^{3}H$ |

# What are isotope ?

- Different forms of same atom
- Have same Atomic Number but different Mass Numbers
- Same number of protons but different number of neutrons



## What is Atomic mass?

- It is weighted average of all the naturally occurring isotopes.
- Contribution in mass due to different isotopes

$^{12}C$ = 99 · 1 → $\frac{99}{100} \times 12 = 11.88$

$^{13}C$ = 1 · 1 → $\frac{1}{100} \times 13 = 0.13$

$^{14}C$ = 100 x

✓ 12.01

Atomic mass

| Element | ~~Mass Number~~ |
|---|---|
| Hydrogen | 1.00784 |
| Carbon | 12.011 |
| Nitrogen | 14.0067 |
| Oxygen | 15.999 |
| Phosphorus | 30.974 |
| Sulphur | 32.065 |

H

1 ← mono-isotopic mass

1.008 ← weighted average of all isotopes

## Atomic mass/weight Unit?

H = 1 atomic mass unit (amu)
C = 12 amu
N = 14 amu
O = 16 amu, unit, Dalton

1 amu or Dalton = $1.67 \times 10^{-24}$ gram

## Isotope

- Elements having the same atomic number but different mass number
- Example: $^{12}C$, $^{13}C$ and $^{14}C$

## Isobar

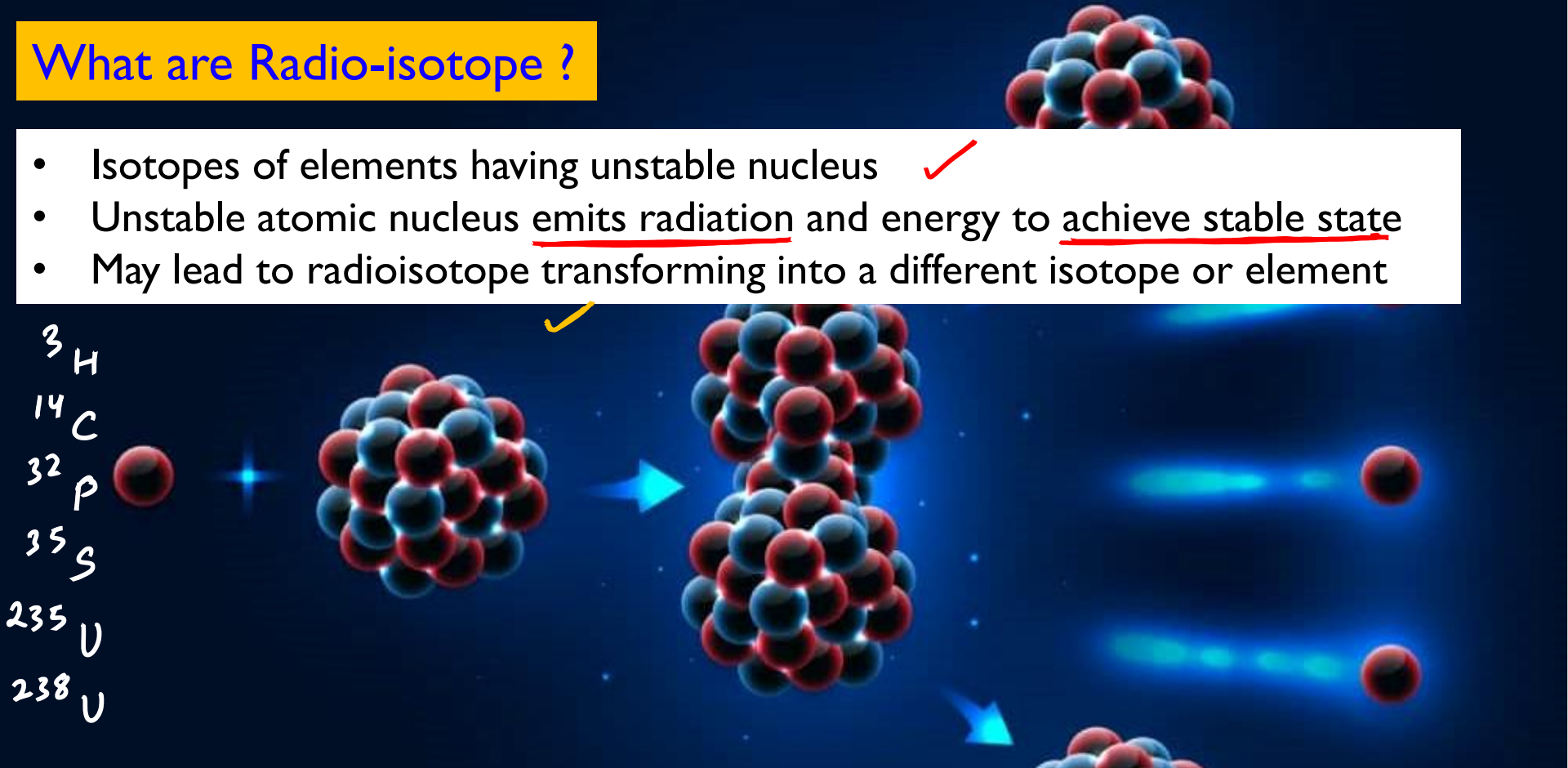
- Elements that have different atomic numbers same mass number
- Example: $^{14}C$ and $^{14}N$

## Isotone

- Elements which have the same number of neutrons.
- Example: $^{12}_{6}C$ (6 neturons) and $^{13}_{7}N$ (6 neutrons)

# What are Radio-isotope ?

- Isotopes of elements having unstable nucleus
- Unstable atomic nucleus emits radiation and energy to achieve stable state
- May lead to radioisotope transforming into a different isotope or element

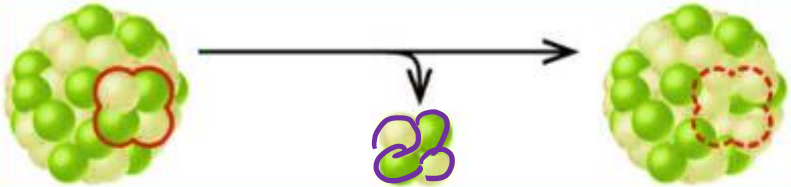
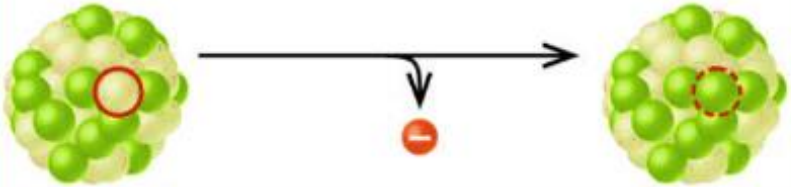
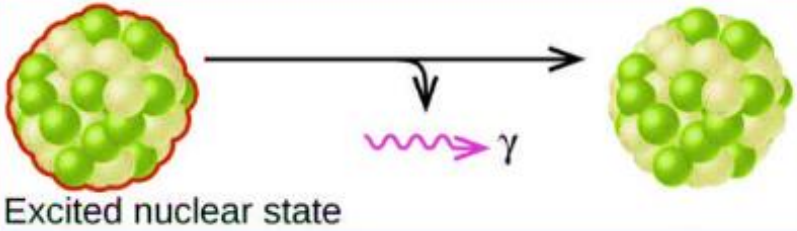


## Examples of Radiation

- Alpha particles:
  Positive charged and mass equal to nucleus of Helium atom


- Beta particles: Only charge no mass (similar to electron)
  - Negatron (Negative charge), Atomic number ↑ by 1
  - Position (Positive Charge), Atomic number ↓ by 1

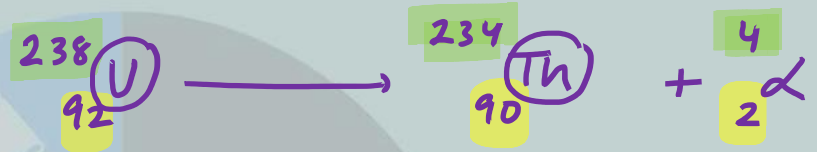
- Gamma rays : No charge or mass, only energy
  Similar to photon.

| Type | Nuclear equation | Representation | Change in mass/atomic numbers |
|---|---|---|---|
| Alpha decay | ${}^{A}_{Z}X \rightarrow {}^{4}_{2}He + {}^{A-4}_{Z-2}Y$ |  | A: decrease by 4<br>Z: decrease by 2 |
| Beta decay<br>Negatron | ${}^{A}_{Z}X \rightarrow {}^{0}_{-1}e + {}^{A}_{Z+1}Y$ |  | A: unchanged<br>Z: increase by 1 |
| Gamma decay | ${}^{A}_{Z}X \rightarrow {}^{0}_{0}\gamma + {}^{A}_{Z}Y$ |  | A: unchanged<br>Z: unchanged |

Penetration power = $\gamma > \beta > \alpha$

## Alpha Decay:

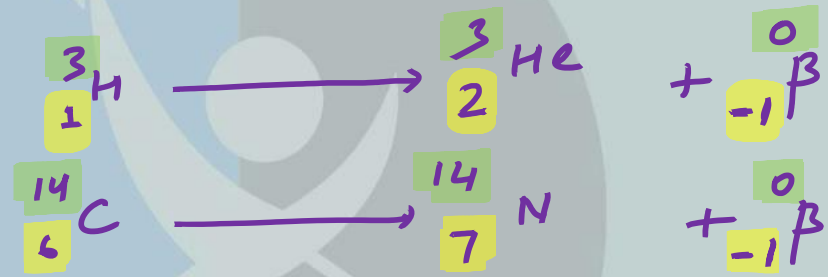
$^{238}$Uranium → $^{234}$Thorium




## Beta Decay (Negatron):

$^{3}H \rightarrow {}^{3}He$

$^{14}C \rightarrow {}^{14}N$

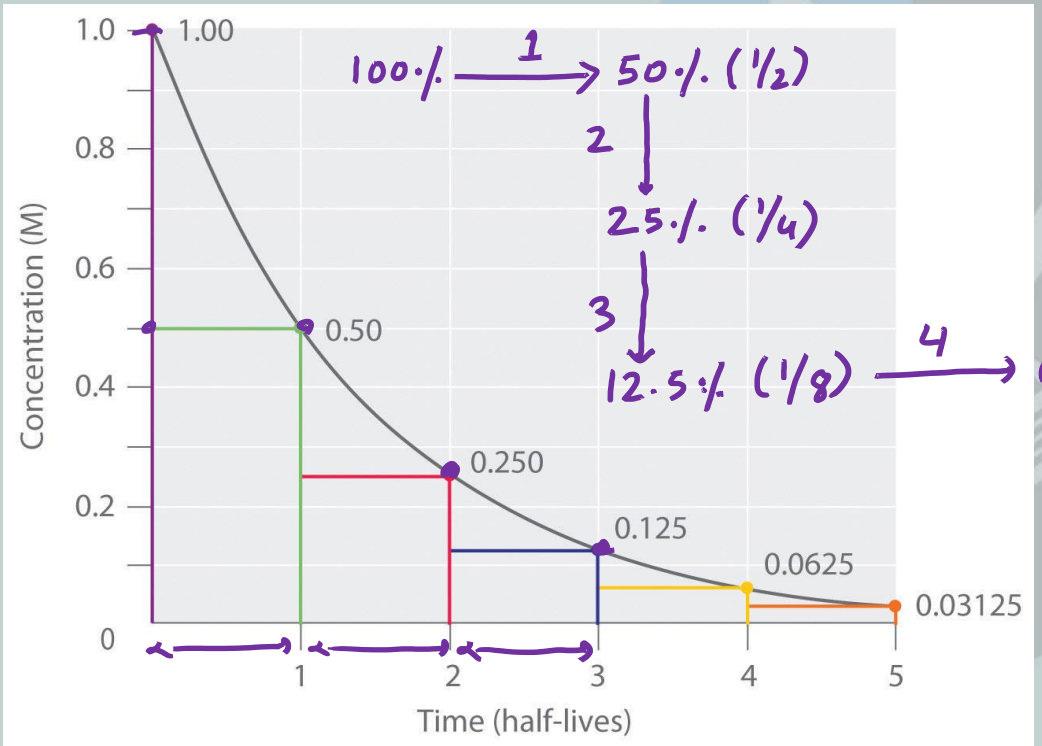



## Gamma Decay:

$^{60}Co$, $^{131}I$

# What is Half Life Radio-isotope ?

It is the time it takes for half of a given amount of the isotope to decay.




$$T_{1/2} = \frac{\ln 2}{k}$$

$$T_{1/2} = \frac{0.693}{k}$$

$k$ : Disintegration constant

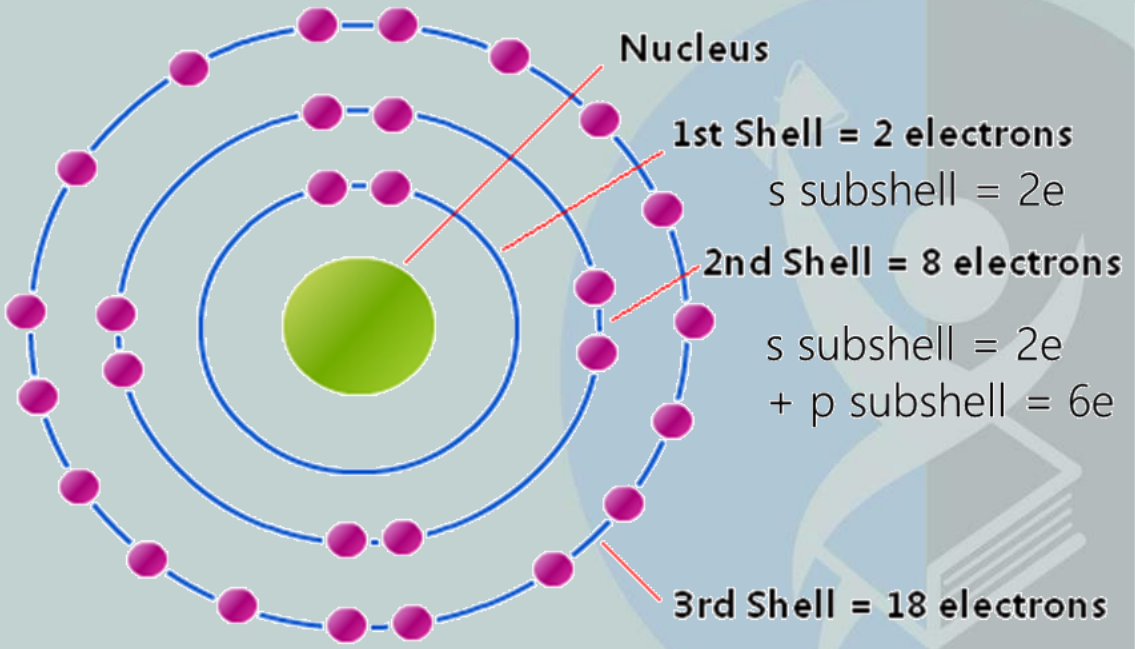
# Half Life of Radio-isotope Used in Biology

$^{14}C$ (unstable) → Time → $^{14}N$ (stable)

| Radio Isotope | Half Life | Type of Radiations |
|---|---|---|
| P-32 | 14.3 Days | Strong Beta Rays |
| S-35 | 87.4 Days | Weak Beta Rays |
| H - 3 | 12.3 Years | Weak Beta Rays |
| C-14 | 5730 Years | Weak Beta Rays |
| C-60 | 5.3 Years | Beta and Gamma Rays |
| K-40 | 1250 Million Years | Beta Decay and Electron Capture |
| U-235 | 700 Million Years | Alpha Rays |
| U-238 | 4500 Million Years | Alpha Rays |

# How electrons are arranged around nucleus?

Shell → subshell → orbital → Electron




Electrons orbit in pairs spinning opposite directions

s subshell = 1 orbital (2e)

p subshell = 3 orbitals (6e)

d subshell = 5 orbitals (10e)

| Shell number | 1 | 2 | | 3 | | | 4 | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Shell name | K | L | | M | | | N | | | |
| Subshell name | 0 | 0 | 1 | 0 | 1 | 2 | 0 | 1 | 2 | 3 |
| Subshell Number | s | s | p | s | p | d | s | p | d | f |
| Number of electron in subshells | 2 | 2 | 6 | 2 | 6 | 10 | 2 | 6 | 10 | 14 |
| Orbitals → | | 1 | 3 | 1 | 3 | 5 | 1 | 3 | 5 | 7 |
| Total number of electrons in subshell | 2 | 8 | | 18 | | | 32 | | | |

Shell Subshell Orbital

K S 1 → 2 electron

L S 1 → 2
P 3 → 6 } 8

M S 1 → 2
P 3 → 6
d 5 → 10 } 18

Number of electrons in shell $= 2n^2$

n = shell number

K = 1 M = 3 O = 5

L = 2 N = 4

Electrons of an atom fill the orbitals in order—the first shell before the second…..

| | Element | Electron shell I | II | III |
|---|---|---|---|---|
| 1 | Hydrogen | ● | | |
| 2 | Helium | ●● | | |
| 6 | Carbon | ●● | ●●●● | |
| 7 | Nitrogen | ●● | ●●●●● | |
| 8 | Oxygen | ●● | ●●●●●● | |
| 10 | Neon | ●● | ●●●●●●●● | |
| 11 | Sodium | ●● | ●●●●●●●● | ● |
| 12 | Magnesium | ●● | ●●●●●●●● | ●● |
| 15 | Phosphorus | ●● | ●●●●●●●● | ●●●●● |
| 17 | Chlorine | ●● | ●●●●●●●● | ●●●●●●● |
| 18 | Argon | ●● | ●●●●●●●● | ●●●●●●●● |

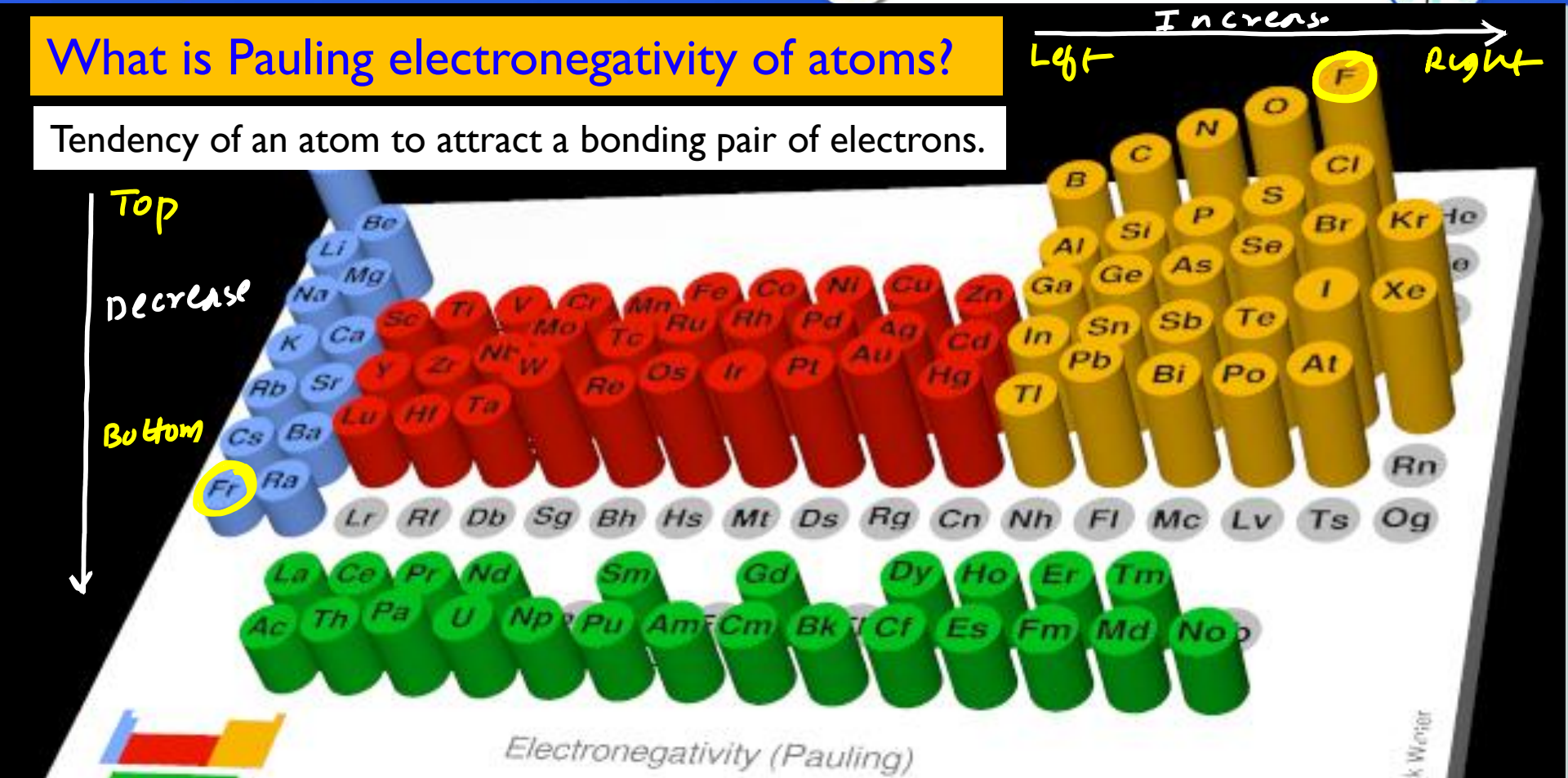

C H O
N P S

If outermost shell is completely filled (He, Ne, Ar)

- Elements are stable
- Inert
- Non-reactive

# What is Pauling electronegativity of atoms?

Tendency of an atom to attract a bonding pair of electrons.



## Order of electronegativity of atoms

O (3.44) > N (3.04) > S (2.58) > C (2.55) > H (2.2) > P (2.19)

O > N > S C > H P

Na & Cl

If atoms has very high difference in electro-negativity = Transfer of electrons ✓

If atoms has very low difference in electro-negativity = Sharing of electrons

High electro-negativity: More solvation of atoms

O, N

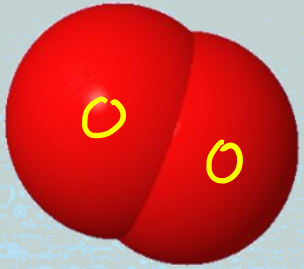
in water

# What Is a Molecule?

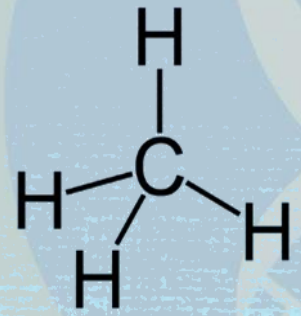
$[Na^+ \cdots Cl^-]$ Ionic bond

A MOLECULE IS AN ELECTRICALLY NEUTRAL GROUP OF ATOMS JOINED TOGETHER BY CHEMICAL BONDS

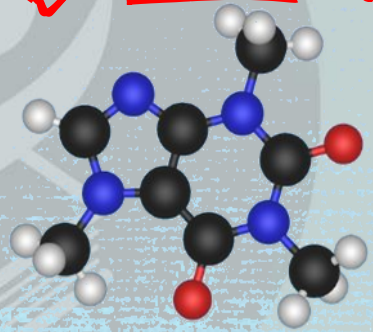
Covalent bond



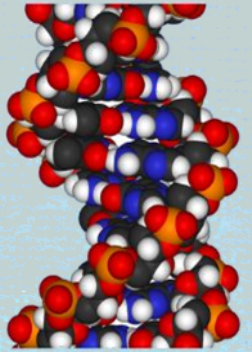

$H_2$ $O_2$ $N_2$ $Cl_2$ Oxygen




Methane



Caffeine



DNA

# thank you

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